PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G11B 7/24, 7/26

A1

(11) International Publication Number: WO 98/50914

(43) International Publication Date: 12 November 1998 (12.11.98)

(21) International Application Number: PCT/IL98/00212

(22) International Filing Date: 7 May 1998 (07.05.98)

(30) Priority Data:
60/045,985 8 May 1997 (08.05.97) US

(71) Applicant *(for all designated States except US)*: OMD OPTICAL MEMORY DEVICES LTD. [IL/IL]; Prof. Bergman Street 2, Science Park Rabin, 76327 Rehovot (IL).

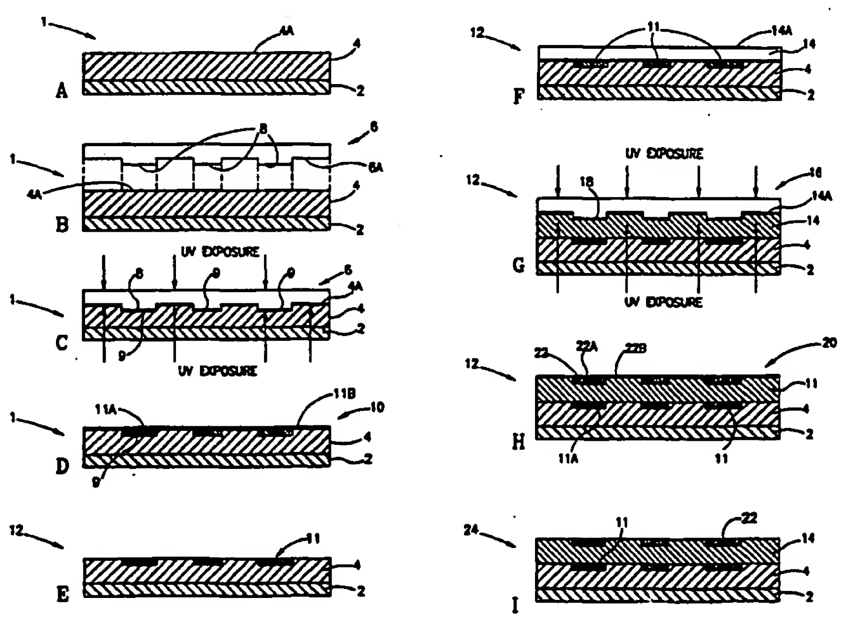
(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: GLUSHKO, Boris [IL/IL]; P.O. Box 3342, 77132 Ashdod (IL). KRUPKIN, Vladimir [IL/IL]; Reuven Ve Bat Sheva 5/27, 75357 Rishon LeZion (IL).

(74) Agent: REINHOLD COHN AND PARTNERS; P.O. Box 4060, 61040 Tel Aviv (IL).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: AN OPTICAL MEMORY DEVICE AND A METHOD OF MANUFACTURING THEREOF



(57) Abstract

The optical memory device has at least one data layer formed on a substrate. An upper surface of the substrate is formed with a pattern comprising a plurality of regions, which are capable of obtaining, when covered by a recording medium, desired optical properties different from those of the substrate. The patterned surface of the substrate is coated with the recording medium. The recording medium is removed from the patterned surface after the recording regions have obtained the desired optical properties.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

An Optical Memory Device and a Method of Manufacturing Thereof

FIELD OF THE INVENTION

The present invention relates to methods for manufacturing optical memory devices such as compact discs (CD), tapes, cards, wires, cylindrical drums, or the like, the information from which is read out by optical means.

BACKGROUND OF THE INVENTION

Compact discs are known optical memory devices, which are widely used particularly with playback and computer devices for retrieving musical and software compositions. Such devices typically comprise only one information-carrying layer and, therefore, suffer from a limited amount of recorded data.

Three-dimensional optical memory devices have been developed typically comprising a plurality of parallel, spaced-apart layers having information carrying regions in which optical properties differ from those of adjacent regions of the layers. One example of such a device is disclosed in U.S. Patent No. 4,090,031. The device comprises a substrate and a plurality of data layers provided on one side of the substrate. Each of the layers comprises

data tracks formed of lines of data spots. The data spots are, in turn, formed of either binary coded digital information or frequency or pulse length modulated analog information, which is photographically recorded. The data spots are light reflective. Selection of one data track for playback is accomplished by changing the focus of a reading light beam from one data layer to another, or by making the data tracks of materials having different optical properties, the reading light being of different wavelengths for different layers. To this end, different color dyes or different photoluminescent materials are used and corresponding color filters are selectively positioned in front of light detectors.

The device is manufactured in the following manner. The data layers are made of photosensitive, reflective material such as photographic film or another suitable recording material including printing ink. The data spots are formed of light reflecting metal material having a reflecting index different from that of the data layers. The data spots are fabricated by either vapor deposition through a mask having an aperture corresponding to the data spots, or etching through a photoresist mask.

It is thus evident that such a device suffers from multiple over-reflection when retrieving the information from the layers. Indeed, a reading beam would pass through all the layers, wherein each layer is reflective. This results in the number of layers being limited to two or three layers only. Additionally, such a technology based on the use of a photomask does not provide high information density, and is, therefore, not effective. It is appreciated that a process of manufacturing of such a device is very complicated and time-consuming. It is also understood that an extremely expensive technique is required for the production of each layer and, thereby, the entire process is very expensive. This makes the process unsuitable for mass production.

SUMMARY OF THE INVENTION

It is a major object of the present invention to provide a novel method of manufacturing an optical memory device, particularly such a method, which is suitable for mass production of the optical memory devices.

It is a further object of the present invention to provide such a method, which enables to manufacture a multi-layered optical memory device.

It is a still further object of the present invention to provide such a method, which is suitable for manufacturing a recordable optical memory device.

There is thus provided according to one aspect of the present invention a method of manufacturing an optical memory device having a data layer formed on a substrate, the method comprising the steps of:

(a) forming an upper surface of the substrate with a pattern having a plurality of regions which are capable of obtaining, when covered by a recording medium, desired optical properties different from those of the substrate;

(b) coating the patterned surface of the substrate with the recording medium; and

(c) removing the recording medium from the patterned surface after the recording regions have obtained the desired optical properties.

In the step (a), the pattern may be in the form of a surface relief on the upper surface of the substrate. This may be achieved by forming the upper surface of the substrate with a plurality of recesses, for example, by means of a stamper device. Alternatively, the substrate itself may be in the form of a stamper substrate, in which case the method may also comprise, subsequently to the step (c), the step of placing an optical film onto the stamper substrate so that the recording medium filled in the recesses of the stamper substrate is stuck to the film in the regions corresponding to the recording regions of the

stamper substrate. Each of the recesses has a sufficient depth to be at least partially filled with the recording medium.

The pattern may be formed by means of forming the upper surface of the substrate with regions having adsorbing properties for adhering the recording medium thereto. This may be achieved by either processing the substrate at respective regions, or coating respective regions with an adsorbing material capable of holding thereon the recording medium.

The substrate is made of a transparent material. The recording medium may be made of a fluorescent or scattering material. Additionally, the recording medium may be multi-layered, being formed, for example, of a reflective material coated by a fluorescent material.

According to another aspect of the present invention there is provided a method of manufacturing a three-dimensional optical memory device formed of a plurality of spaced-apart data layers each formed on a substrate, the method comprising the steps of:

(i) forming an upper surface of each of the substrates with a pattern comprising a plurality of regions which are capable of obtaining, when covered by a recording medium, desired optical properties different from those of the substrate;

(ii) coating the patterned surface of the substrate with the recording medium;

(iii) removing the recording medium from the patterned surface after the recording regions have obtained the desired optical properties; and

(iv) providing an attachment between the data layers.

According to yet another aspect of the invention, there is provided an optical memory device comprising a transparent data layer having an upper surface thereof patterned with a plurality of spaced-apart recording regions formed of a material having optical properties different from those of the

transparent layer.

According to yet another aspect of the invention, there is provided a multi-layered optical memory device comprising a plurality of spaced-apart transparent layers, each layer having an upper surface thereof patterned with a plurality of spaced-apart recording regions formed of a material having optical properties different from that of the transparent layer.

More specifically the present invention is used for manufacturing multi-layered compact discs and is, therefore, described below with respect to this application.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how the same may be carried out in practice, several preferred embodiments will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figs. 1a to 1i illustrate a method of manufacturing a multi-layered optical disc according to one embodiment of the present invention;

Figs. 2a to 2f illustrate a method according to another embodiment of the present invention;

Figs. 3a to 3i illustrate a method according to yet another embodiment of the present invention;

Figs. 4a to 4d illustrate a method according to yet another embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to Figs. 1a-1i, there are illustrated the main steps of a method for manufacturing an optical disc, according to one embodiment of the invention. The method is based on a so-called "photopolymer curing

technique". Fig. 1a shows a structure, generally designated **1**, which comprises a support base **2** formed of a transparent material such as, for example, glass, polyester, polycarbonate, coated with a substrate layer **4** formed of a liquid photopolymer. For example, the layer **4** may be made of such materials as UV lacquer 1322 000 40039 or the like, commercially available from Phillips Coating B.V., Holland, or UV adhesive Kayarad DVD-003 or the like, commercially available from Nippon Kayaku Co. Ltd. The thickness of the base **2** is within a range of 0.02-1.2 mm, while the substrate layer **4** is substantially thin being of about 5-30

Fig. 1b illustrates a durable stamper **6** having a patterned outer surface **6a** that is formed with a specific arrangement of a plurality of convexities or so-called "stamper bumps", generally at **8**. The convexities **8** are typically of 0.3-0.5 50-200% of the convexity length. The convexity's height and length are variable, depending on an encoded information which have to be stored in the disc. The convexities occupy about 10-30%, and preferably 20%, of the stamper's surface **6a**. The stamper **6** is made of a transparent material so as to allow UV illumination to pass therethrough, as will be described further below. The stamper **6** is typically manufactured from a so-called "master disc"" using one of the conventional mastering and replication processes, which are widely used in the optical disc memory industry, applying such known techniques as laser beam recording, photoresist developing, electroplating, electroforming, etching, disc molding, etc. These techniques are known *per se* and, therefore, need not be specifically described. The stamper **6** could be manufactured by etching a master glass or quartz disc with a developed photoresist layer.

The stamper **6** is applied to the structure **1** by means of pressing it against an upper surface **4a** of the substrate layer **4**. As shown in Fig. 1c, this results in providing a pattern on the surface **4a**, the pattern being similar to that of the surface **6a**. More specifically, the surface **4a** is formed with a

corresponding plurality of recesses or pits, generally at **9**, arranged similar to the convexities **8**. Ultra-violet (UV) light is radiated through either the transparent substrate **2** or transparent stamper **6** in order to cure the photopolymer **4** and, in the patterned form, adhere the latter to the substrate **2**.

Thereafter, a working layer **10** is deposited onto the patterned surface **4a** of the substrate layer **4**, as shown in Fig. 1d. The layer **10** is made of a liquid material **11** (constituting a recording medium) such as, for example, fluorescent material containing an organic or non-organic dye, photochromic material, scattering material like a white paint, reflective material like a metal paint, etc. The fluorescent material is a solution of a fluorescent substance in a solvent monomer or in a mixture of various polymers, elastomers and solvents. It should be noted that the material **11** for the working layer **10** is chosen so as to have good adhesion properties to the substrate layer **4** in order to provide durability of the memory device.

It is understood, that the liquid substance **11** partly penetrates into the recesses **9**, defining regions **11a** within the recesses **9**, and, due to a strong adhesion, partly remains on the surface **4a**, defining regions **11b** located between the recesses **9**. The thickness **D** of the regions **11a** is substantially equal to recesses' depth, while, in order to optimize the coating procedure, the thickness **d** of the regions **11b** is such as to satisfy the following condition:

$$\mathbf{d} \ll \mathbf{D}$$

To this end, the structure **1** is continuously rotated during the deposition of the working material **11**. Initially, the rotation is relatively slow so as to facilitate homogeneous distribution of the working material **11** over the surface **4a**. Thereafter, the rotation is speeded up so as to, on the one hand, remove an excess of the working material **11** from the regions **11b** and, on the other hand, obtain the uniform distribution thereof within the regions **11a**. More specifically, the coating procedure should be such that the thickness **d** of the

layer **10** in the regions **11b** is less than 20% of the thickness **D** of the layer **10** within the regions **11a**.

In order to improve the adhesion, a thermal polymerization or a so-called "baking technique" is used, wherein "baking time" is about 10 minutes or less. Alternatively, an oxidization polymerization could be applied.

In order to remove the remaining working substance **11** from the regions **11b**, although not specifically shown, the substrate layer **4** is washed by a suitable solvent such as, for example, ethanol, tetrafluoropropanol or the like, and dried. To this end, the layer **4** undergoes controllable and highly uniform dissolution by means of simultaneous spinning and spraying thereof by a suitable solvent material. A dispersing head (not shown) is appropriately employed for dispersing the solvent material over the structure **1**. Preferably, the solvent is initially applied to a central area of the structure's surface and, thereafter, to a periphery thereof. A solved fluorescent material is then removed from the rotating structure. In order to improve the removal of the solved fluorescent material from the regions **11b**, the solvent may contain suitable inclusions. Additionally, the dispersing head could be equipped with soft brushes for facilitating the removal of the solved fluorescent material. Both the inclusions and brushes should be, on the one hand, sufficiently soft, so as to prevent possible damage to the substrate layer **4** underneath the regions **11b** and, on the other hand, sufficiently big in size, so as to prevent the removal of the fluorescent material from the regions **11a**.

As clearly illustrated in Fig. 1e, the above results in the provision of the working material **11** within the regions **11a** inside the recesses **9**, the regions **11a** being surrounded by substantially transparent regions **11b** of the layer **4**.

Hence, a one-layer compact disc, generally designated **12**, is provided. The regions **11a** represent data spots formed of the fluorescent material **11**, which are surrounded by the transparent regions **11b** and the substrate layer **4**.

It is important to note that the fluorescent material may be replaced by reflecting, scattering or the like working material, whose optical properties are thereby different from that of the transparent substrate layer.

In order to manufacture a multi-layered structure, the one-layer structure **12** is coated with a further photopolymer layer **14** having an outer surface **14a**. A transparent stamper **16** is applied to the surface **14a** in a manner described above with respect to the stamper **6**, and UV light is radiated onto the layer **14** through the transparent stamper **16**. The absorption of the UV radiation in the layer **14** protects the fluorescent material **11** within the regions **11b** from being bleached by the UV radiation. It is understood that the transparency of the stamper **16** is optional and, alternatively, the UV light may be radiated through the transparent base **2** and cured photopolymer **4**. As a result, the surface **14a** of the photopolymer **14** becomes formed with a plurality of recesses **18**.

A working layer **20** formed of a fluorescent material **22** is laminated onto the patterned surface **14a**, which results in the provision of regions **22a** and **22b** located between and inside the recesses **18**, respectively. Fast spinning, baking, washing and drying processes are, then, repeated for providing a two-layered compact disc, generally designated **24** (Fig. 1i).

It will be readily understood that a desired number of layers can be fabricated in the above-described manner. The number of layers is limited solely by a permissible thickness of the whole optical disc, which is typically about 1-2 mm, in order to be used with a suitable reading device. To this end, a set of "master discs" together with a corresponding set of stampers is previously produced, including about 5-50 different stampers for manufacturing of a multi-layered disc.

Turning now to Figs. 2a-2f, the main steps of a method for manufacturing a multi-layered optical disc are illustrated, which method is based on a so-called "injection molding technique". A structure, generally

designated **100**, comprises a transparent flat base **102** which is coated by a substrate layer **104** formed of an injected resin such as, for example, various grades of polycarbonate, polystyrene, polyester, or the like. To this end, the resin layer **104** is pressed between the flat base **102** and a stamper **106** and is injection molded in a conventional manner for patterning a surface **104a** of the layer **104**. The latter becomes formed with a plurality of specifically arranged recesses **109**.

Thereafter, the base **102** may be removed. The molded surface **104a** is coated by a liquid fluorescent substance **111** which partly penetrates inside the recesses **109** defining regions **111a** and partly remains on the surface **104** defining regions **111b** between the recesses **109**. The obtained structure is spun so as to remove an excess of the fluorescent material **111** from the regions **111b** and baked so as to settle the fluorescent material **111** within the regions **111a**. The layer **104** is washed and the whole structure is spun, which results in the provision of a one-layer memory device **112**, in which the regions **111b** are cleaned from the fluorescent substance **111**, while, owing to the adhesion processes, the latter remains within the regions **111a**.

A next layer **114** of the irreversible resin is injection molded in a manner described above applying another stamper **116**, so as to form a surface **114a** of the layer **114** with a plurality of recesses **119**. A fluorescent material **120** is deposited onto the surface **114a**, so as to be located solely within regions **120a** inside the recesses **119**, as shown in Figs. 2e and 2f in a self-explanatory manner. Two layers **112** are bound together by means of either UV adhesives as described above or thermoplastic hot melt adhesives such as, for example, thermoplastic clastomer Macromelt Q 8740 or the like, commercially available from Henkel Corp., U.S.A. Thus, a double-layered disc **122** is constructed.

Reference is now made to Figs. 3a-3I, which illustrate the main steps

of a method for manufacturing a multi-layered optical disc according to another example of the invention. A structure **200** is provided, being formed of a glass or ceramic base **202** coated by a substrate layer **204** made of a photoresist material **205**. As shown in Fig. 3b, the photoresist layer **204** is appropriately exposed through a photomask **206** in a conventional manner, so-called "modern photolitography". This results in the provision of a desired pattern **208** formed of a plurality of regions **209a** of the photoresist material **205** specifically arranged on a surface **202a** of the base **202** defining thereby regions **209b** located between the regions **209a**. The patterned structure is then dipped into a fluorescent dye solution **210** contained in a vessel **211**. It is appreciated that both the photoresist and fluorescent material are chosen such that the photoresist material is capable of adsorbing this fluorescent material.

The fluorescent dye **210** partly penetrates into the photoresist material **205** within the regions **209a** and partly remains within the regions **209b** (Fig. 3d). To this end, the base **202** should be either formed of or coated by a material resistant to the dye penetration. Obviously, if such a protective coating is applied, it is chosen so as to allow for easy removal thereof from the regions **209b**, when desired.

Thereafter, although not specifically illustrated, the fluorescent material **210** is removed from the regions **209b** by washing and cleaning procedures as described above. As shown in Fig. 3e, the resulted structure is coated by an additional layer **212** which is made of a transparent material **213**, for example, the same photoresist mixture but without the light sensitive components. If the photoresist **205** is based on Polymetilmetacrylat (PMMA), then the latter could be used as the material **213** for the additional layer **212**. The illumination of the layer **212** with UV light and/or baking provides desirable hardening and protection. Hence, a one-layer disc, generally designated **214**, is provided.

As shown in Fig. 3g, in order to provide a multi-layered structure, a further layer **216** made of a photoresist material **217** is deposited on the layer **212** and exposed through a photomask **218**, so as to obtain a desired pattern formed of a plurality of regions **220a** of the photoresist material, which are specifically arranged on a surface of the layer **216** defining regions **220b** between the regions **220a**. It is appreciated that further processes of inserting the fluorescent dye into the regions **220a**, removing the dye from the regions **220b** and coating the structure by an intermediate protective layer would complete a two-layered optical disc.

Yet another example of a method according to the invention is now described with reference to Figs. 4a-4d. A structure, generally at **300**, which comprises a thin substrate layer **302** formed of a polycarbonate material is injection molded in the above described manner applying a stamper **304**. As a result, a specific arrangement of recesses **306** is obtained on an outer surface of the substrate layer **302**.

A first, relatively thin, working layer **308** is provided by depositing a reflective metal, for example, aluminum, chromium or the like, onto the patterned surface of the substrate layer **302**, defining thereby regions **308a** inside the recesses **306** and regions **308b** between the recesses **306**. The thickness of the layer **308** within the regions **308b** between the recesses should be substantially less than the depth of the recesses **306**.

The reflective layer **308** is coated by a second working layer **310** made of a fluorescent material **311** such as, for example, organic monomer, polymer or the like dielectric material. The thickness of the layer **310** should be higher than that of the layer **308** within the regions **311b** between the recesses **306**. To this end, such procedures as spin coating, deep coating, extrusion, or the like could be performed. Additionally, the fluorescent material **311** should be of an etching rate substantially less than that of the

reflective metal of the first working layer **308**.

Both the reflective and fluorescent materials are removed from the regions between the recesses **306**, by means of a suitable known technique, for example, etching, polishing, chemical polishing, etc. A one-layer disc, generally designated **312**, is provided, the disc being composed of a transparent substrate layer **302** having its upper surface formed with the recording regions **311a**. In distinction to the previously described examples, the recording regions **311a** are formed of the reflective material **308** coated by the fluorescent material **311**.

It is appreciated that the provision of such a reflective material underneath the fluorescent material, on the one hand, increases the fluorescence of the material **311** and, on the other hand, provides a desired protection for the substrate layer **302** when removing therefrom the excess of the fluorescent material **311**. Obviously, although not specifically shown, a multi-layered structure may be obtained by gluing the devices **312** to each other in the above-described manner.

It is desired to eliminate or at least substantially reduce the reflection of the device **312** with respect to reading light. This may be achieved by oxidizing the metal layer **308** from a corresponding side thereof. To this end, a chromium oxide should preferably be used as the material for the lower surface of the layer **308**.

It is thus evident that the present invention, in comparison to the prior art techniques for the manufacture of optical discs, in which reflective recording regions are spaced by reflective substrate regions, enables to significantly increase the data density of an optical memory device. Indeed, according to the conventional approach, the height of the recording region should be about */4*, wherein is a wavelength of reading light. On the contrary, according to the present invention, there are no limitations to the recesses' height, owing to the fact that the transparent substrate regions

surround them. Additionally, it is understood that the greater the length of the recording region, the more the recorded data contained therein. According to the conventional approach, the increase of the length of the recording region is the only solution for increasing the recorded data contained therein. However, this length is always limited. On the contrary, the present invention enables to increase the recorded data contained within the recording region by increasing the recesses' height. This allows for making the recesses with a minimum possible length, and, therefore, for making more recesses within each data layer.

It should be specifically noted that the present invention may be used for manufacturing a so-called "recordable optical disc". In this case and with reference, for example, to Figs. 1a-1e, the pattern is in the form of a spiral-like recess **9** provided in the upper surface **4a** of the substrate layer **4**. The recess **9** is filled with the fluorescent material **11** in the above-described manner.

Those skilled in the art will readily appreciate that various modifications and changes may be applied to the invention as hereinbefore exemplified without departing from its scope defined in and by the appended claims.

CLAIMS:

1. A method of manufacturing an optical memory device having a data layer formed on a substrate, the method comprising the steps of:

(a) forming an upper surface of the substrate with a pattern having a plurality of regions which are capable of obtaining, when covered by a recording medium, desired optical properties different from those of the substrate;

(b) coating the patterned surface of the substrate with the recording medium; and

(c) removing the recording medium from the patterned surface after the recording regions have obtained the desired optical properties.

2. The method according to Claim 1, wherein the pattern is in the form of a surface relief on the upper surface of the substrate.

3. The method according to Claim 2, wherein said surface relief is formed of a plurality of spaced-apart recesses in the upper surface of the substrate.

4. The method according to Claim 3, wherein said recesses are made using a stamper device.

5. The method according to Claim 3, wherein each of said recesses has a sufficient depth to be at least partially filled with the recording medium.

6. The method according to Claim 3, wherein the substrate is in the form of a stamper substrate.

7. The method according to Claim 6, and also comprising the step of:

(d) placing an optical film onto the stamper substrate so that the recording medium filled in the recesses of the stamper substrate is stuck to the film in regions corresponding to the recording regions on the stamper substrate.

8. The method according to Claim 1, wherein the pattern comprises a plurality of spaced-apart regions having adsorbing properties for adhering the recording medium thereto.

9. The method according to Claim 8, wherein the adsorbing regions are made by processing the substrate in respective regions.

10. The method according to Claim 8, wherein the adsorbing regions are formed by coating respective regions of the upper surface of the substrate with an adsorbing material capable of holding thereon the recording medium.

11. The method according to Claim 1, wherein the substrate is made of a transparent material.

12. The method according to Claim 1, wherein the recording medium is made of a fluorescent material.

13. The method according to Claim 11, wherein the recording medium is made of a reflective material.

14. The method according to Claim 11, wherein the recording medium is made of a scattering material.

15. The method according to Claim 11, wherein the recording medium is in the form of a reflective material coated by a fluorescent material.

16. A method of manufacturing a three-dimensional optical memory device formed of a plurality of spaced-apart data layers each formed on a substrate, the method comprising the steps of:

(i) forming an upper surface of each of the substrates with a pattern comprising a plurality of regions which are capable of obtaining, when covered by a recording medium, desired optical properties different from those of the substrate;

(ii) coating the patterned surface of the substrate with the recording medium;

(iii) removing the recording medium from the patterned surface after the recording regions have obtained the desired optical properties;

(iv) providing an attachment between the data layers.

17. An optical memory device comprising a transparent data layer

having an upper surface thereof patterned with a plurality of spaced-apart recording regions formed of a material having optical properties different from the transparent layer.

18. The device according to Claim 17, wherein the recording regions are formed of a fluorescent material.

19. The device according to Claim 17, wherein the recording regions are formed of a reflective material.

20. The device according to Claim 17, wherein the recording regions are formed of a scattering material.

21. The device according to Claim 17, wherein the recording regions are formed of a reflective material coated by a fluorescent material.

22. A multi-layered optical memory device comprising a plurality of spaced-apart transparent layers, each layer having an upper surface thereof patterned with a plurality of spaced-apart recording regions formed of a material having optical properties different from the transparent layer.

23. The device according to Claim 22, wherein the recording regions are formed of a fluorescent material.

24. The device according to Claim 22, wherein the recording regions are formed of a reflective material.

25. The device according to Claim 22, wherein the recording regions are formed of a scattering material.

26. The device according to Claim 22, wherein the recording regions are formed of a reflective material coated by a fluorescent material.

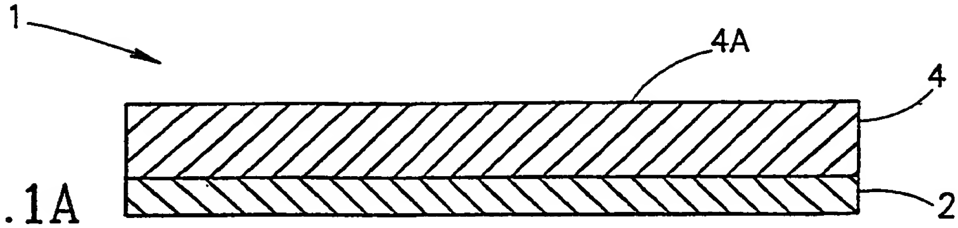


FIG.1A

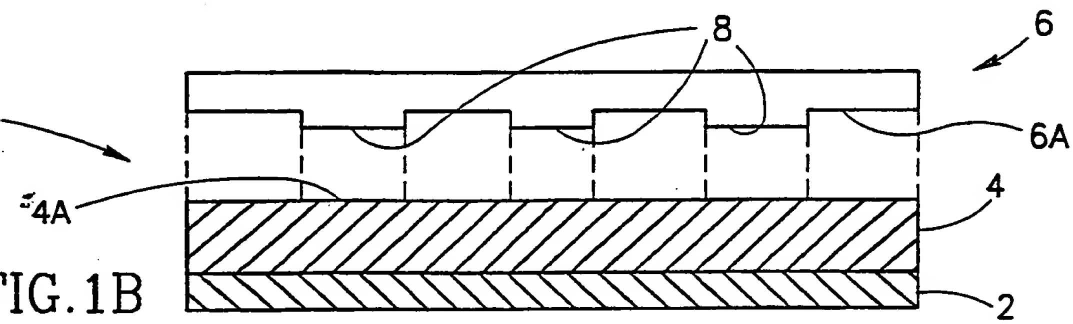


FIG.1B

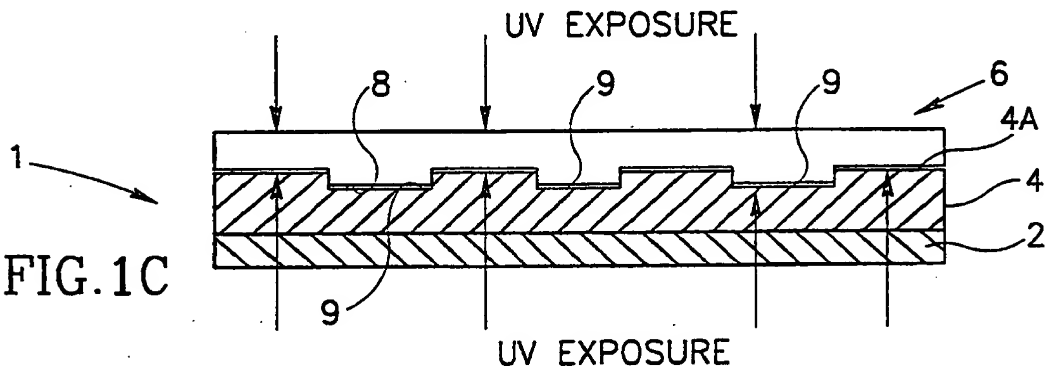


FIG.1C

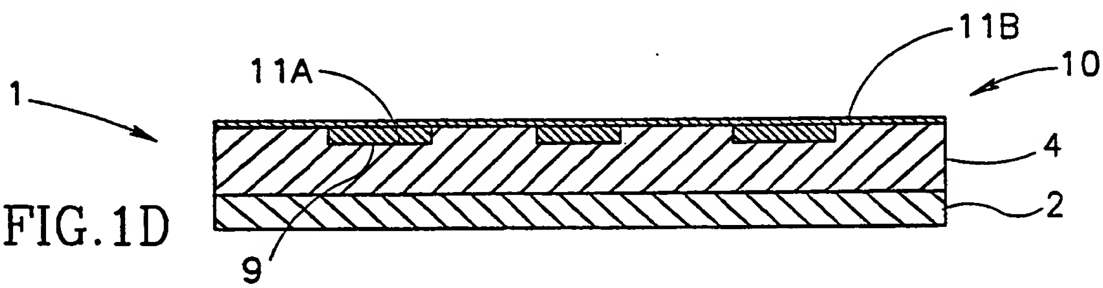


FIG.1D

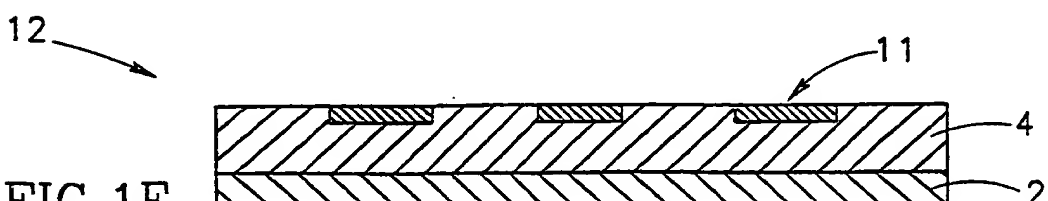


FIG.1E

2/7

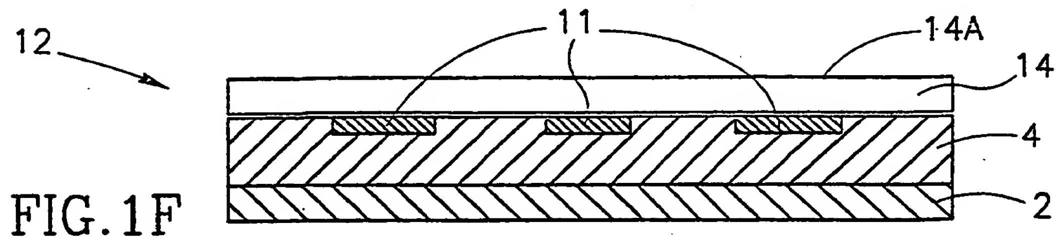


FIG. 1F

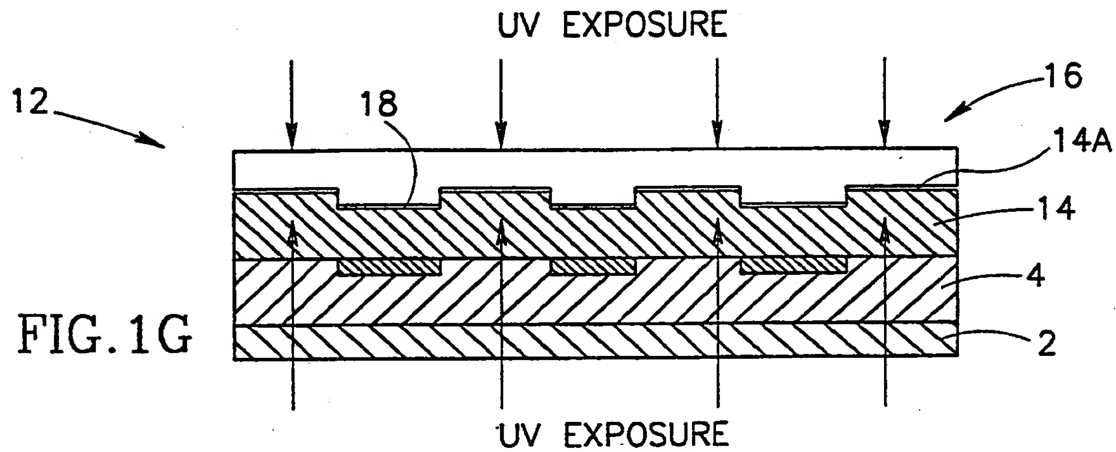


FIG. 1G

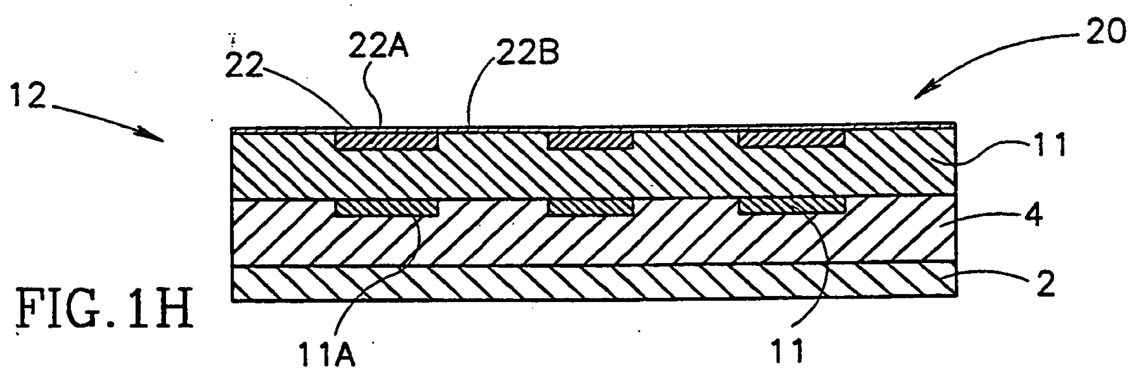


FIG. 1H

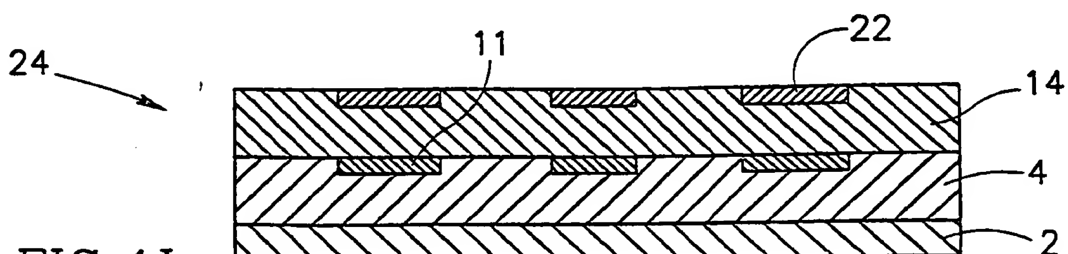


FIG. 1I

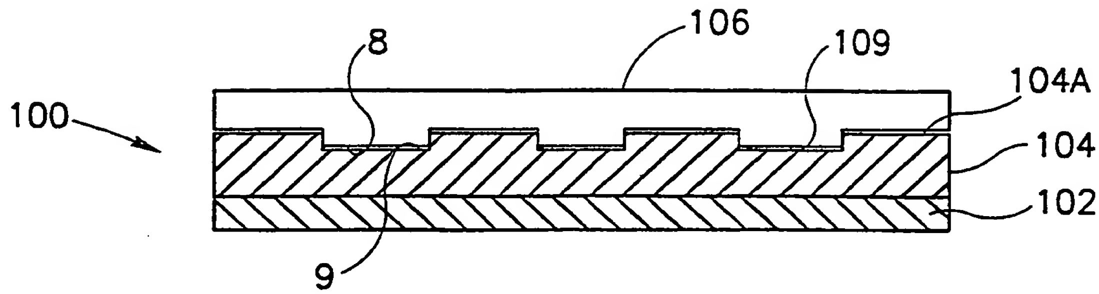


FIG.2A

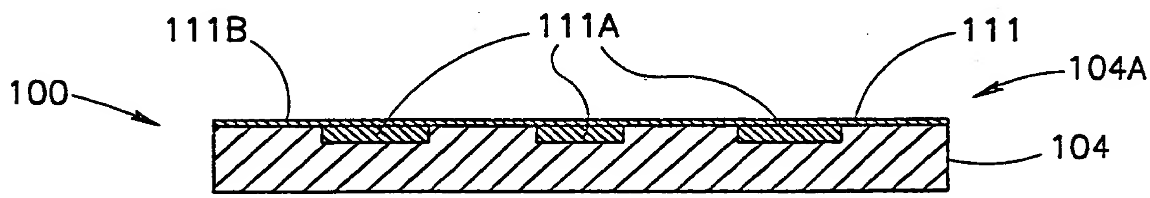


FIG.2B

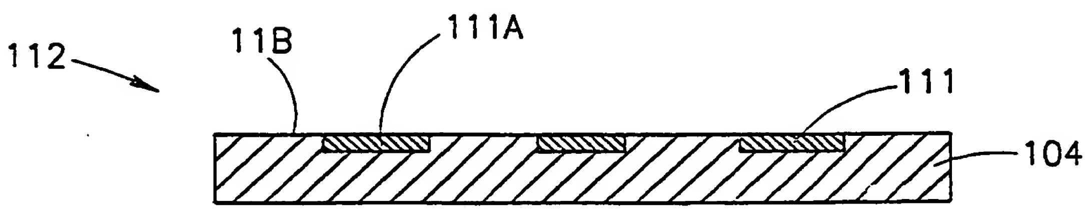


FIG.2C

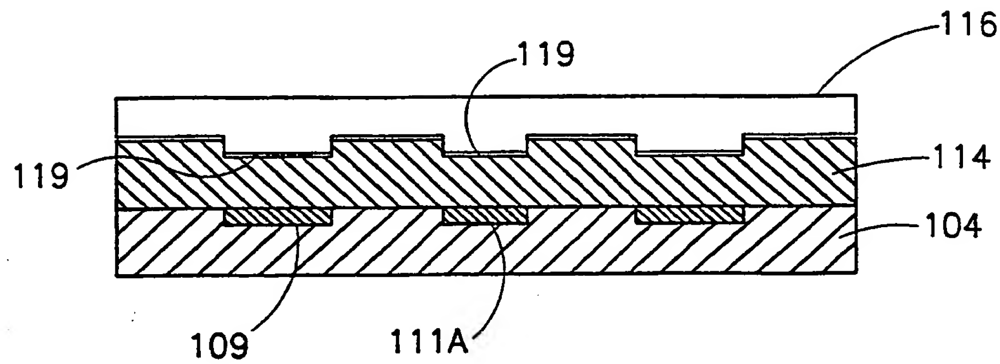


FIG.2D

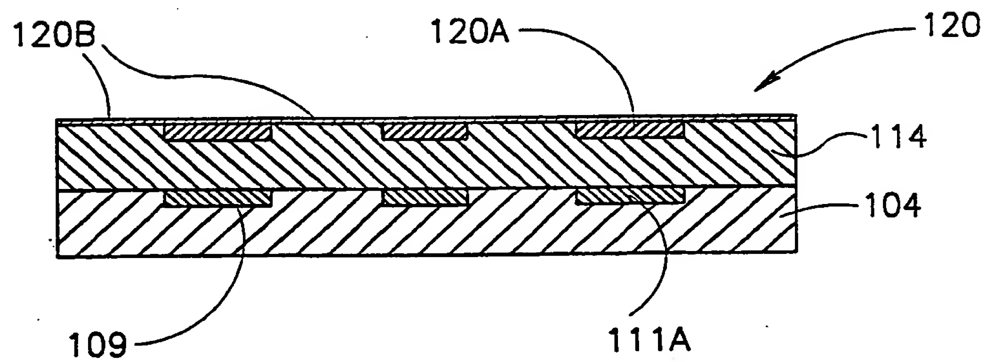


FIG.2E

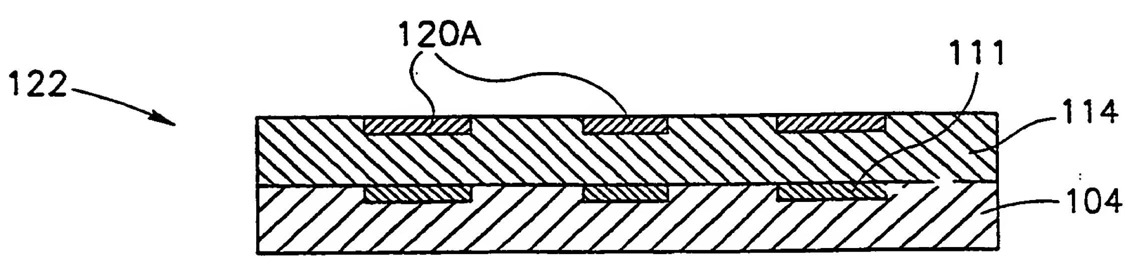


FIG.2F

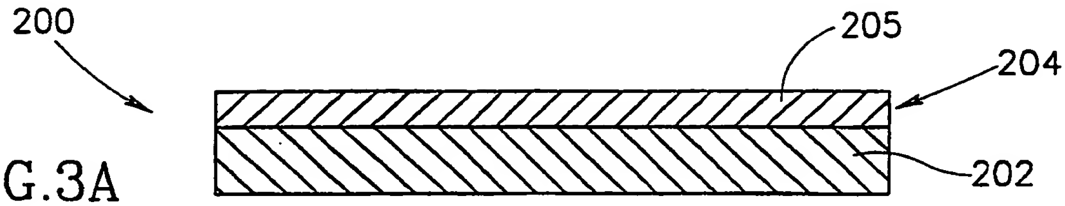


FIG.3A

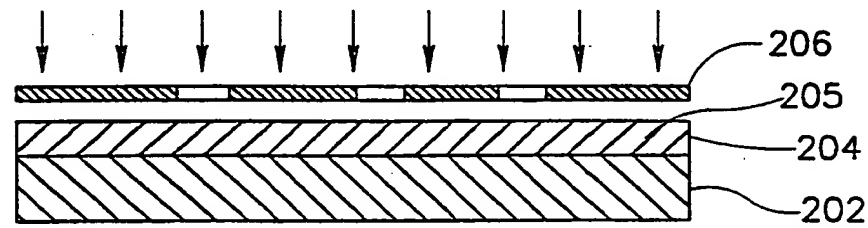


FIG.3B

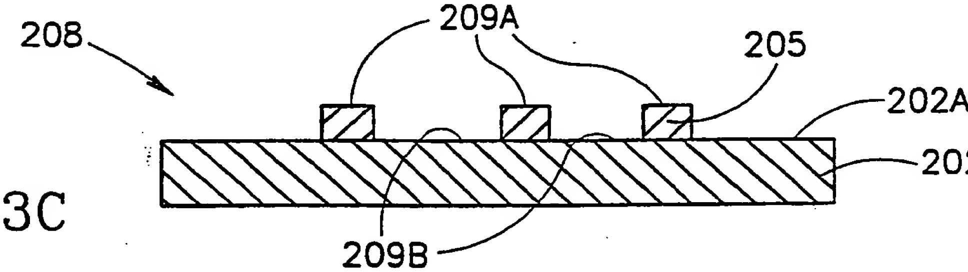


FIG.3C

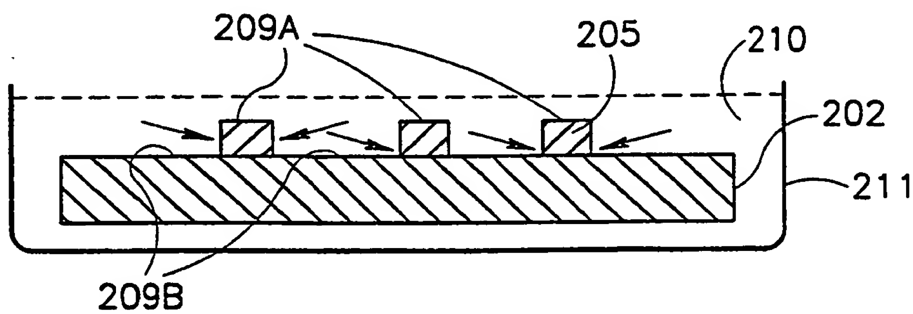


FIG.3D

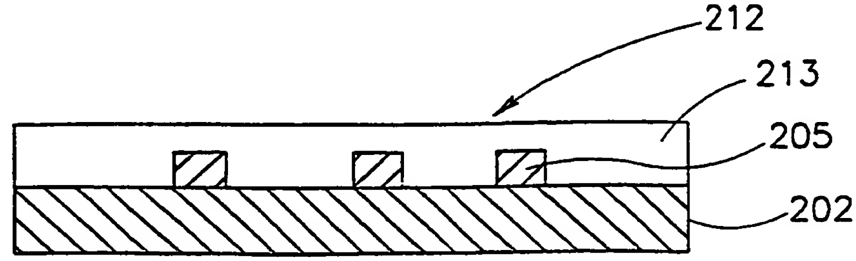


FIG.3E

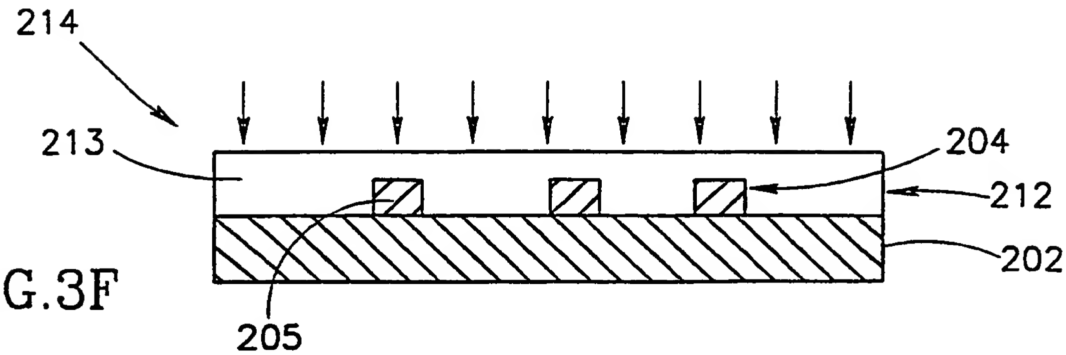


FIG.3F

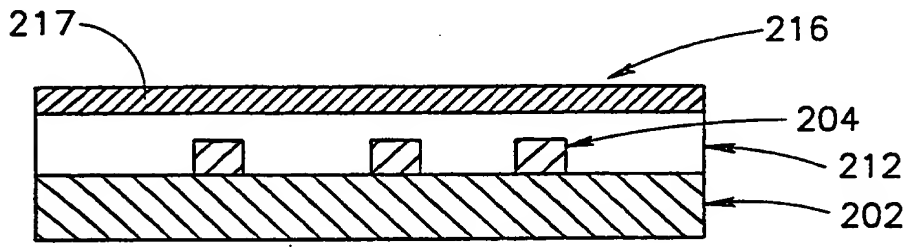


FIG.3G

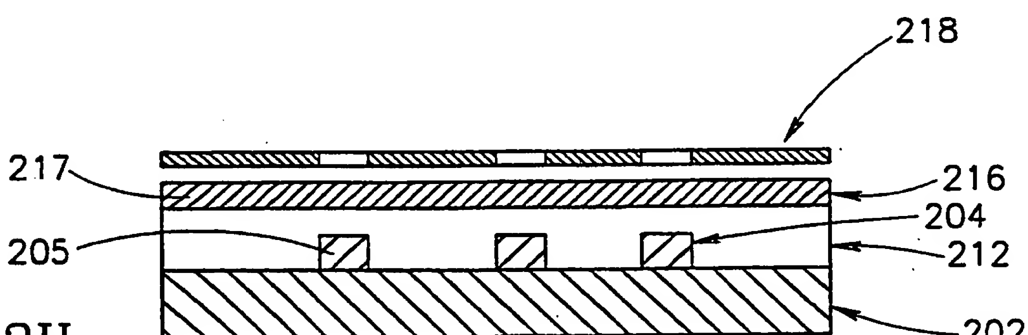


FIG.3H

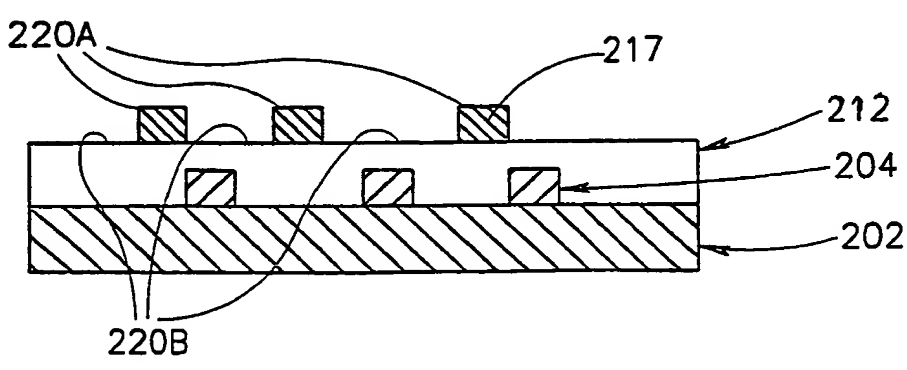


FIG.3I

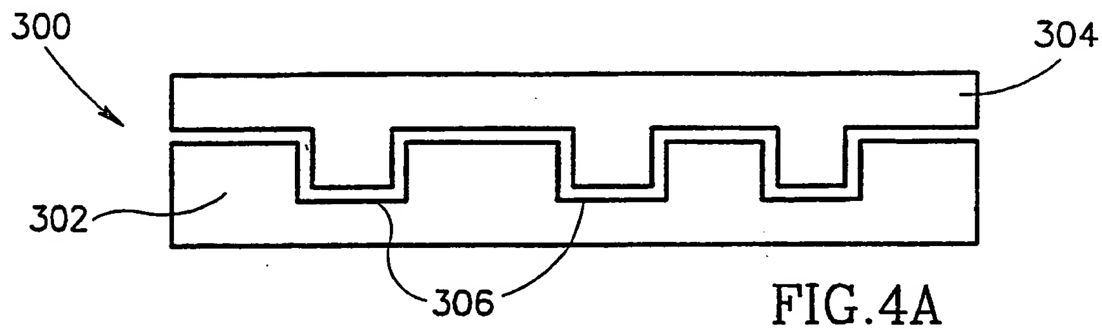


FIG.4A

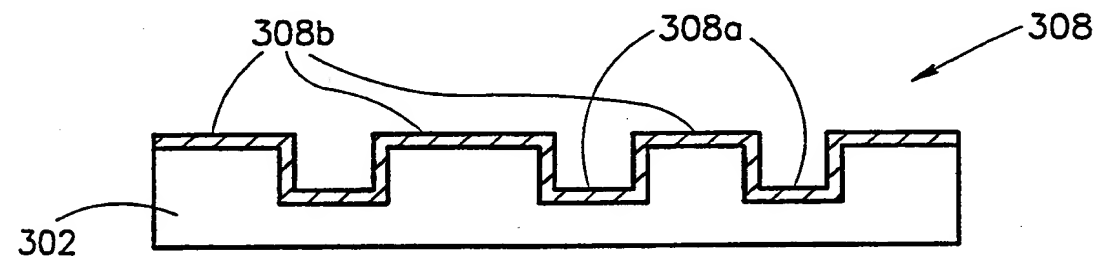


FIG.4B

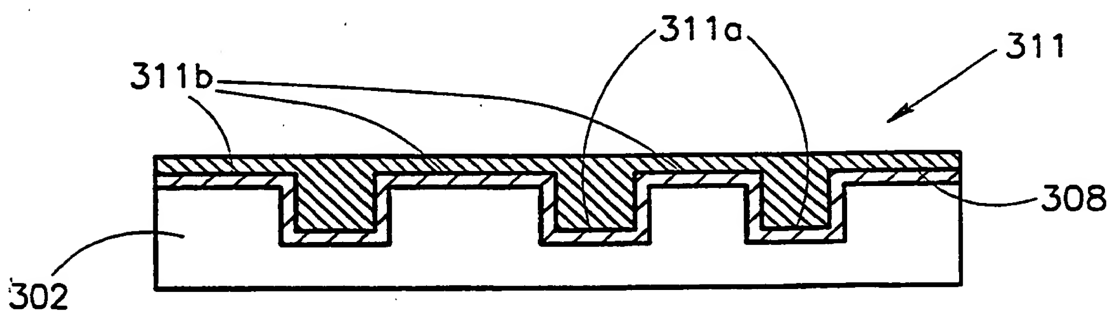


FIG.4C

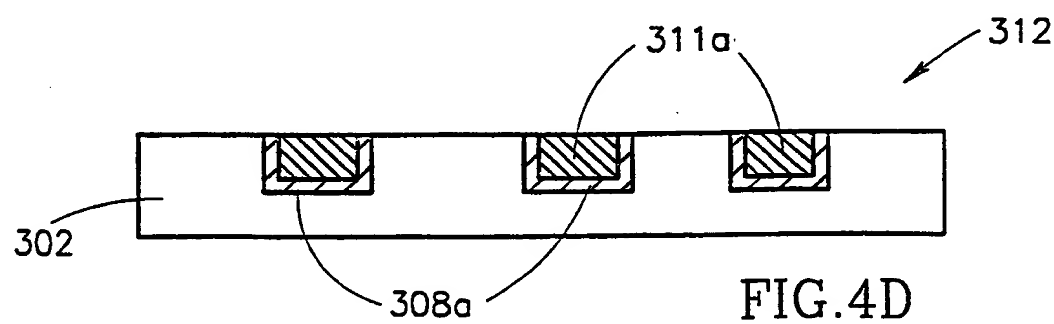


FIG.4D

INTERNATIONAL SEARCH REPORT

Inte tional Application No
PCT/IL 98/00212

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G11B7/24 G11B7/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G11B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 197 256 A (GERBER ARTHUR M) 15 October 1986 see page 22, line 11 - page 23, line 20; figure 8	1-5,11, 13,17,19
X	EP 0 177 311 A (ICI PLC ;TDK CORP (JP)) 9 April 1986	1-5,8,17
A	see the whole document	9,10
X	FR 2 702 080 A (DIGIPRESS SA) 2 September 1994 see the whole document	17
A	WO 93 21638 A (MARTIN MARIETTA ENERGY SYSTEMS) 28 October 1993 see page 15, line 31 - page 16, line 25; figures 7,8	17,20, 22,25

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 August 1998	01/09/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Holubov, C

2

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IL 98/00212

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 373 491 A (TERAO MOTOYASU ET AL) 13 December 1994 see the whole document ---	17,18, 22,23
A	WO 91 11804 A (DYNO PARTICLES AS) 8 August 1991 see page 20, line 28 - page 21; figure 11 -----	17

2

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/IL 98/00212

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0197256 A	15-10-1986	CA 1255791 A	13-06-1989
		JP 62078748 A	11-04-1987
		US 4855984 A	08-08-1989
		US 4811326 A	07-03-1989
		US 4811331 A	07-03-1989
		US 4812218 A	14-03-1989
		US 4807218 A	21-02-1989
EP 0177311 A	09-04-1986	JP 61165839 A	26-07-1986
FR 2702080 A	02-09-1994	NONE	
WO 9321638 A	28-10-1993	US 5325342 A	28-06-1994
		AU 2934292 A	18-11-1993
		CA 2131813 A,C	28-10-1993
		EP 0635157 A	25-01-1995
		IL 103357 A	14-05-1996
		JP 2709651 B	04-02-1998
		JP 6503198 T	07-04-1994
US 5373491 A	13-12-1994	DE 4218036 A	03-12-1992
		JP 5151615 A	18-06-1993
WO 9111804 A	08-08-1991	NO 179886 B	23-09-1996
		AT 107068 T	15-06-1994
		AU 7142191 A	21-08-1991
		DE 69102421 D	14-07-1994
		DE 69102421 T	29-09-1994
		DK 513062 T	14-11-1994
		EP 0513062 A	19-11-1992
		ES 2057861 T	16-10-1994
		LV 11390 A	20-06-1996
		LV 11390 B	20-10-1996
		US 5384764 A	24-01-1995